

## **Editorial. ACL Injury in the Female Athlete: A Multifactorial Problem That Remains Poorly Understood**

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### **Abstract:**

Since 1996, when the first report of sex differences in neuromuscular function appeared in the literature with the aim of understanding why physically active females are at greater risk of injuring the ACL than their male counterparts, many authors have reported on sex differences in neuromuscular and biomechanical function. Based on this collective literature, clear sex differences in muscle activation and movement patterns have been identified, leading to the focus on neuromuscular and biomechanical factors as the key reasons for the sex differences in ACL injury rates. In turn, prevention programs have been developed to reduce dynamic knee loading through neuromuscular training.

**Keywords:** ACL injury | sex differences | female athletes | risk factors

### **Article:**

Since 1996, when the first report of sex differences in neuromuscular function appeared in the literature with the aim of understanding why physically active females are at greater risk of injuring the ACL than their male counterparts, many authors have reported on sex differences in neuromuscular and biomechanical function. Based on this collective literature, clear sex differences in muscle activation and movement patterns have been identified, leading to the focus on neuromuscular and biomechanical factors as the key reasons for the sex differences in ACL injury rates. In turn, prevention programs have been developed to reduce dynamic knee loading through neuromuscular training.

Good evidence exists for the effectiveness of these prevention programs, but we still do not know which facet(s) of these programs are responsible for the injury decrease. Through which mechanisms are risk factors modified? What are the short-term versus long-term effects? When is the best time to intervene? To answer these questions, we still need to know the underlying mechanisms for sex differences in neuromuscular and biomechanical function and the extent to

which these differences truly predict increased injury risk. In other words, why do females demonstrate greater functional valgus collapse, tend to land with less hip and knee flexion, and show earlier and stronger quadriceps activation patterns relative to the hamstrings—and are all of these factors truly problematic? In fact, we know very little about the underlying causes for these sex differences—anatomical, hormonal, or otherwise—critical information if we are to develop the most effective intervention strategies and identify those athletes at the greatest risk of suffering an ACL injury.

With this focus in mind, “Research Retreat IV: ACL Injuries—The Gender Bias” was held in Greensboro, North Carolina, in April 2008. The purpose of this retreat was to continue to examine the factors thought to be associated with females' increased risk of ACL injuries and to do so via keynote presentations by nationally and internationally known experts in the field, abstract presentations of original research conducted by attendees, and focused discussions. At meeting's end, a consensus document that was developed during previous retreats of what we know, don't know, and still need to know in relation to this problem was revised and updated based on new research. We are pleased to include here the keynote presentation summaries, presentation abstracts, and updated consensus statement from the conference. Specifically, the keynote summaries by Scott McLean, PhD, and Bruce Beynnon, PhD, address the current theories and findings related to neuromuscular and biomechanical risk factors and anatomical and hormonal risk factors, respectively. Presentation abstracts are organized thematically, focusing on sagittal-plane alterations in landing mechanics; sex comparisons and fatigue and perturbation studies in landing and cutting; and anatomical and hormonal factors and risk factor screening and prevention. The consensus statement presents the current state of knowledge and important future directions related to neuromuscular and biomechanical, anatomical and structural, and hormonal risk factors and risk factor screening and prevention strategies.

The retreat was an excellent opportunity for clinicians and researchers to come together to share their most recent work, stay current with ongoing research, and discuss and develop new research directives aimed at understanding the underlying causative factors in noncontact ACL injury and the reasons for females' increased risk of injury. From our discussions, 3 important themes emerged. First, we need a clear working definition of a noncontact ACL injury. Second, it is time to move beyond the purely descriptive sex comparison studies that continue to dominate the literature and more critically examine the underlying causes for these differences and whether they truly reflect an increased injury risk for the physically active female. In reality, we have yet to “connect the dots” among the underlying causative factors, adverse knee joint neuromechanics, and injury risk. Third, we need a more integrative approach to risk factor assessment (versus continued examination of isolated risk factors) as well as our reporting of the neuromuscular and biomechanical outcomes associated with the examination of these risk factors. In time, we believe that these strategies will lead to a more comprehensive and accurate understanding of the most relevant risk factors that negatively affect weight-bearing knee-joint function in a way that leads to injury and will strengthen the foundation upon which optimal prevention and rehabilitation strategies can be developed. To achieve these goals, we need larger-scale, multifactorial studies. The National Athletic Trainers' Association Research & Education Foundation, National Institutes of Health, and other funding agencies have played a critical role in advancing ACL research. Their future support will be even more important as we take on increasingly complex study designs to answer this perplexing dilemma.

Conference co-organizers Dr Randy Schmitz, Dr “Yum” Nguyen, and I hope that the information presented here will continue to encourage high-quality and relevant research in this very important area.